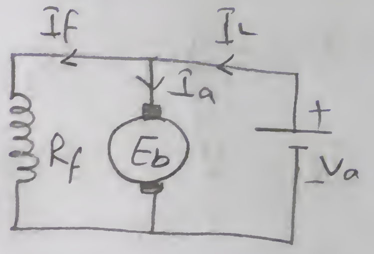
sheet (2)

D.C. Motor

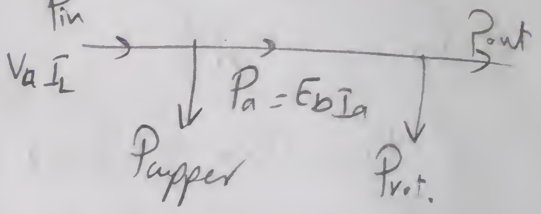
(1) $P_{out} = 3.37\,kW$, $N_m = 1725\,rpm$, $V_a = 125\,V$, shunt, $\eta = 0.825$ at full load Req: (1) P_{in} (2) I_{Line} (3) T_{out}

Solution

$$\eta = \frac{P_{o/p}}{P_{i/p}} * 100 \qquad \therefore 0.825 = \frac{3.37}{P_{in}}$$



$$\therefore \boxed{P_{in} = 4.084\,kW} \#$$



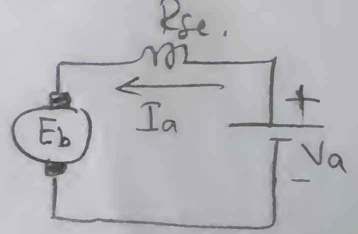
$$P_{in} = V_a \cdot I_L$$

$$\therefore I_L = \frac{4084.848}{125} = \boxed{32.678\,A} \#$$

$$T_{out} = \frac{P_{out}}{\omega_m} = \frac{3.37 * 10^3}{\left(\frac{\pi * 1725}{30}\right)} = \boxed{18.655\,N.m} \#$$

(2) $V_a = 250\,V$, $R_a = 0.06\,\Omega$ & $I_{a1} = 25\,A \longrightarrow N_{m1} = 850\,rpm$, Series
$I_{a2} = 18\,A$ Req: N_{m2} for $V_{a2} = V_{a1}$, $R_{se} = 0.025\,\Omega$

Solution



$$E_{b1} = V_{a1} - I_{a1}(R_a + R_{se})$$

$$= 250 - 25(0.06 + 0.025)$$

$$\therefore \boxed{E_{b1} = 247.875\,V}$$

$$E_{b2} = V_{a2} - I_{a2}(R_a + R_{se})$$

$$= 250 - 18(0.06 + 0.025)$$

$$\therefore \boxed{E_{b2} = 248.47\,V}$$

$\because E_b \propto I_f\, \omega_m \Rightarrow$ for series motor $E_b \propto I_a\, \omega_m$

$$\therefore \frac{E_{b1}}{E_{b2}} = \frac{I_{a1} \cdot N_{m1}}{I_{a2} \cdot N_{m2}} \qquad \therefore N_{m2} = \frac{I_{a1}\, E_{b2}}{I_{a2}\, E_{b1}}$$

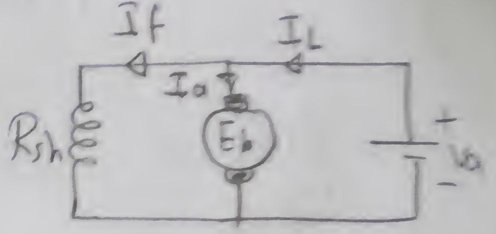
$$\therefore \boxed{N_{m2} = 1183.389\,rpm} \#$$

) $R_a = 0.1\,\Omega$, $N_{m1} = 1000\,rpm$, $250 = V_{a1}$ Shunt Motor, $R_{sh1} = 25$

$P_{i/p} = 6.5\,kW$, if $V_{a2} = 230\,V$, $R_{sh2} = 125\,\Omega$

Req: N_{m2} to keep T_L = Cost.

Solution



at $V_{a1} = 250\,V$

$$I_{a1} = I_{L1} - I_{f1} \quad , \quad I_{L1} = \frac{P_{i/p}}{V_{a1}} = 26A$$

$$I_{f1} = \frac{V_{a1}}{R_{sh1}} = \frac{250}{250} = 1A$$

$$\therefore \boxed{I_{a1} = 25A}$$

$$\therefore E_{b1} = 250 - 25 * 0.1 = 247.5\,V$$

for keeping T_L const. , $T \propto I_f I_a$

$$\therefore \frac{T_{L1}}{T_{L2}} = \frac{I_{a1} I_{f1}}{I_{a2} I_{f2}} = 1$$

$$, \; I_{f2} = \frac{V_{a2}}{R_{sh2}} = \frac{230}{125} = 1.84\,A$$

$$\therefore I_{a2} = I_{a1} \frac{I_{f1}}{I_{f2}} = \boxed{13.587A}$$

$$\therefore E_{b2} = 230 - 13.587 * 0.1 = \boxed{228.6413\,V}$$

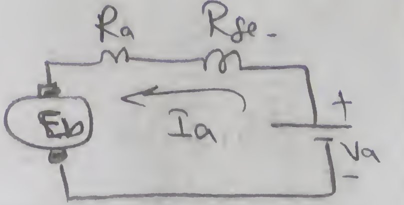
$$\because E_b \propto I_f \omega_m$$

$$\therefore N_{m2} = N_{m1} * \frac{E_{b2} I_{f1}}{E_{b1} I_{f2}}$$

$$\therefore \boxed{N_{m2} = 502\,rpm}$$

السرعة قلت نتيجة الـEb قل و تيار المجال زاد

ries motor, $R_a = 0.1\,\Omega$, $R_{se.} = 0.05\,\Omega$, $V_a = 600\,V$, $I_{a1} = 150\,A$
$N_{m1} = 3000\,rpm$, $N_{m2} = 2000\,rpm$, Req.: R_{add} series with armature
To keep T_L const.



Solution

$$E_{b1} = V_{a1} - I_{a1}(R_a + R_{se.})$$

$$\therefore E_{b1} = 600 - 150(0.1 + 0.05)$$

$$\therefore \boxed{E_{b1} = 577.5\,V}$$

for T_L const., $\because T_L \propto I_a^2$ in series motor

$$\therefore I_{a1} = I_{a2}$$

$$\therefore \frac{E_{b1}}{E_{b2}} = \frac{N_{m1}}{N_{m2}} \qquad \therefore E_{b2} = E_{b1}\frac{N_{m2}}{N_{m1}}$$

$$\therefore \boxed{E_{b2} = 385\,V}$$

$$E_{b2} = V_a - I_{a2}(R_{add} + R_a + R_{se.})$$

$$\therefore 385 = 600 - 150(R_{add} + 0.15)$$

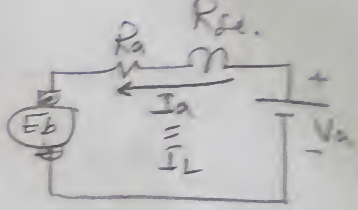
$$\therefore 215 = 150(R_{add} + 0.15)$$

$$\therefore R_{add} + 0.15 = 1.433$$

$$\therefore \boxed{R_{add} = 0.98\,\Omega} \ \#$$

(5) Series $R_a = 0.1\,\Omega$, $R_{se.} = 0.1\,\Omega$, $N_m = 400\,rpm$, $P_{in} = 60\,KW$ at $V_{a1} =$
if $V_{a2} \longrightarrow 400\,V$, $R_{ins.} = 2.5$, $T_{L2} = \frac{1}{2} T_{L1}$ find $N_{m2} = ?$

Solutions



$P_{in} = V_a . I_L \therefore I_{L1} = I_{a1} = \frac{P_{in}}{V_{a1}} = \frac{60000}{500} = 120A$

$E_{b1} = V_{a1} - I_{a1}(R_a + R_{se.})$

$\therefore E_{b1} = 500 - 120 * 0.2$

$\therefore \boxed{E_{b1} = 476\,V}$

$\because R_{inserted} \therefore flux \downarrow\downarrow \therefore I_a \downarrow\downarrow$

$\therefore T \propto I_a^2 \quad \therefore \frac{T_{L1}}{T_{L2}} = \frac{I_{a1}^2}{I_{a2}^2}, \quad T_{L2} = \frac{1}{2} T_{L1}$

$\therefore \frac{1}{\frac{1}{2}} = \frac{I_{a1}^2}{I_{a2}^2} \quad \therefore I_{a2} = \sqrt{\frac{120^2}{2}} = \boxed{84.85A}$

$\therefore E_{b2} = V_{a2} - I_{a2}(R_a + R_{se.} + R_{ins})$

$\therefore E_{b2} = 400 - 84.85(0.2 + 2.5)$

$\therefore \boxed{E_{b2} = 170.905\,V}$

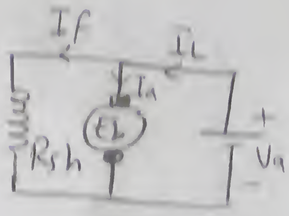
$\therefore N_{m2} = N_{m1} \frac{E_{b2}\, I_{a1}}{E_{b1}\, I_{a2}}$

$\therefore \boxed{N_{m2} = 203.1127\ rpm}$ #

$= 250\,V$, $R_{sh_1} = 250\,\Omega$, $R_a = 0.25\,\Omega$, $N_{m_1} = 1500\,rpm$, $I_{a_1} = 20\,A$

$\&$ $R_{sh_2} = 500\,\Omega$ $T_{L_1} = T_{L_2}$ Req: ① $N_{m_2} = ?$ ② $I_{a_2} = ?$

Solutions



$E_{b_1} = V_{a_1} - I_{a_1} R_a = 250 - 20 * 0.25$

$\therefore \boxed{E_{b_1} = 245\,V}$

$I_{f_1} = \dfrac{250}{250} = 1\,A$

$I_{f_2} = \dfrac{250}{500} = 0.5\,A$

$\because T_{L_1} = T_{L_2}$ $\therefore \dfrac{T_{L_1}}{T_{L_2}} = \dfrac{I_{f_1} \cdot I_{a_1}}{I_{f_2} \cdot I_{a_2}}$ $\therefore I_{a_2} = I_{a_1} \dfrac{I_{f_1}}{I_{f_2}} = \dfrac{1 * 20}{0.5}$

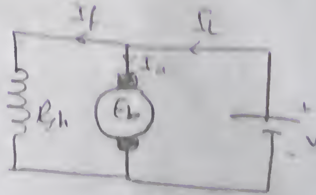
$\therefore \boxed{I_{a_2} = 40\,A}$

$\therefore E_{b_2} = V_a - I_{a_2} R_a = 250 - 40 * 0.25$

$\therefore \boxed{E_{b_2} = 240\,V}$ $\therefore N_{m_2} = N_{m_1} * \dfrac{E_{b_2}\, I_{f_1}}{E_{b_1}\, I_{f_2}} = \boxed{2938.77\ rpm}$

⑦ $R_a = 0.1\,\Omega$, $R_{sh} = 400\,\Omega$, $V_a = 200\,V$ shunt, $I_{L_1} = 10\,A$, $P_{rot} = 100\,W$
$N_m = 400\,rpm$ Req: ① P_a, ② P_{out} ③ η ④ T_{out}

Solutions



$I_{f_1} = \dfrac{V_{a_1}}{R_{sh}} = \dfrac{200}{400} = 0.5\,A$

$\therefore I_{a_1} = 9.5\,A$ $\therefore E_{b_1} = 200 - 9.5 * 0.1 = 199.05\,V$

$\therefore P_a = E_{b_1} I_{a_1} = \boxed{1.891\,kW}$

$P_{in} = V_{a_1} \cdot I_{L_1} = 2\,kW$

$\therefore P_{out} = P_a - P_{rot} = 1.891 - 0.1 = \boxed{1.791\,kW}$

$\therefore \boxed{\eta = 89.55\%}$

$T_{out} = \dfrac{P_{out}}{\omega_m} = \dfrac{1.791 * 10^3}{\left(\dfrac{\pi * 400}{30}\right)} = \boxed{42.756\,N.m}$

$\rightarrow$ if $\phi_2 = \frac{1}{2}\phi_1$ $\therefore I_{f_2} = \frac{1}{2} I_{f_1}$, $I_{a_2} = I_{a_1}$, $V_{a_2} = V_{a_1}$

$\therefore E_{b_2} = E_{b_1} = 199.05\,V$

$\because \dfrac{E_{b_1}}{E_{b_2}} = \dfrac{I_{f_1}\, N_{m_1}}{I_{f_2}\, N_{m_2}}$ ($I_{f_2} = \frac{1}{2} I_{f_1}$) $\therefore 1 = \dfrac{2\, N_{m_1}}{N_{m_2}}$ $\therefore N_{m_2} = 2 N_{m_1}$ #

⑤ $\therefore \boxed{N_{m_2} = 800\,rpm}$

if $T_{L2} = 2T_{L1}$, $V_{a2} = V_{a1}$, $N_{m2} = ?$ (7)

$\because T \propto I_f I_a \quad \therefore \dfrac{T_{L1}}{T_{L2}} = \dfrac{I_{f1} \, I_{a1}}{I_{f2} \, I_{a2}}$

→ Consider I_f const.

$\therefore \dfrac{1}{2} = \dfrac{I_{a1}}{I_{a2}} \quad \therefore I_{a2} = 2 I_{a1}$

$\boxed{I_{a2} = 19 \, A}$

$\therefore E_{b2} = 200 - 19 * 0.1 = 198.1 \, V$

$\therefore \dfrac{E_{b1}}{E_{b2}} = \dfrac{N_{m1}}{N_{m2}} \quad \therefore N_{m2} = N_{m1} \dfrac{E_{b2}}{E_{b1}}$

$\therefore N_{m2} = 400 * \dfrac{198.1}{199.05} = 398.1 \, rpm$

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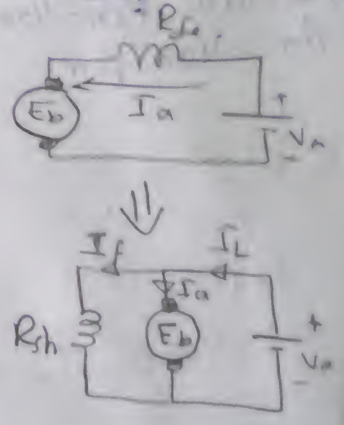
(8) $P = 2$, $N_m = 707 \, rpm$, $I_L = 100 A$, $V_a = 85 V$ series , $R_{se} = 0.03 \, \Omega$
$R_a = 0.04 \, \Omega$ if become shunt $T_{L2} = T_{L1}$ → $N_{m2} = ?$

$E_{b1} = V_a - I_{a1}(R_a + R_{se}) = 85 - 100 * (0.03 + 0.04)$

$\therefore E_{b1} = 78 \, V$



∴ 2 poles, $N_{m1} = 707$ rpm, $I_{L1} = 100$ A, $V_a = 85$ V with field coils in series (Two coils), $R_{se.} = 0.03\ \Omega$, $R_a = 0.04\ \Omega$

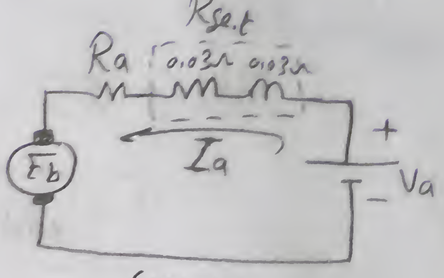
→ if field coils are parallel ∴ ($R_{se.} = \frac{0.03}{2} = 0.015\ \Omega$), $T_{L1} = T_{L2}$

Req: ① $N_{m2} = ?$

② $R_{add} = ?$ to make speed = 707 rpm

Solution

when the two field coils are connected in series ∴ $R_{set} = 0.03 + 0.03 = 0.06\ \Omega$

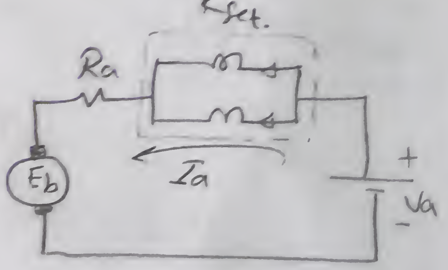


Case (1)

$\therefore E_{b1} = V_a - I_{a1}(R_a + R_{set})$ (series), $I_{L1} = I_{a1}$

$\therefore E_{b1} = 85 - 100 * (0.04 + 0.06)$

$\therefore \boxed{E_{b1} = 75\ V}$



when the two field coils are connected in parallel ∴ $R_{set.\,(shunt)} = \frac{0.03}{2} = 0.015\ \Omega$

the torque is constant

$\therefore T \propto I_a^2$ (series) $\therefore \frac{T_1}{T_2} = \frac{I_{a1}^2}{I_{a2}^2}$ ∴ $I_{a1} = I_{a2} = 100$ A

تيار الحمل لا يزال ثابتاً
رغم توصيل الملفات توازي لأن التيار سوف يتوزع عليهم ويتجمع مرة أخرى (العزم ثابت)

$\therefore E_{b2} = V_a - I_{a2}(R_a + R_{set.})$ (shunt)

$\therefore E_{b2} = 85 - 100 * (0.04 + 0.015) = \boxed{79.5\ V}$

$\boxed{\phi = N I}$

N → نفس الملفات

I → ثابت (قال العزم ثابت)

$\therefore E \propto I_f\, \omega_m$ $\therefore \frac{E_{b1}}{E_{b2}} = \frac{I_{a1} N_{m1}}{I_{a2} N_{m2}}$ $\therefore N_{m2} = N_{m1} \frac{E_{b2}}{E_{b1}}$

$\therefore \boxed{N_{m2} = 749.42\ rpm}$

$R_{add} = ?$ to restore $N_m = 707$ rpm ?

$\therefore N_{m2} = 749.42$ rpm $\longrightarrow E_{b2} = 79.5V$

$\therefore E_b = V_a - I_a (R_a + R_{se})$ $\longrightarrow$ 707 rpm

↳ shunt

E_b → 75V

$\therefore 75 = 85 - 100 * (0.04 + R_{add} + 0.015)$

$\therefore$ $R_{add} = 0.045\,\Omega$

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ries, $V_a = 440\ V$, $R_a + R_{se} = 0.3\ \Omega$

at $R = 0\ \Omega$

$I_{a1} = 20\ A$, $N_{m1} = 1200\ rpm$

at $R = 3\ \Omega$

$I_{a2} = 15\ A$ ① Req: $N_{m2} = ?$

② if $\phi_1 = 8\ mwb$, find $P_a = E_a I_a$, $T_a = P_a . \omega_m$ in each case?

Solution

at $R = 0\ \Omega$

$E_{b1} = V_a - I_{a1}(R_a + R_{se} + R)$, $R \to 0$

$\therefore E_{b1} = 440 - 20\,(0.3)$

$\therefore E_{b1} = 434\ V$

at $R = 3\ \Omega$

$E_{b2} = V_a - I_{a2}(R_a + R_{se} + R)$, $R \to 3$

$\therefore E_{b2} = 440 - 15(0.3 + 3)$

$\therefore E_{b2} = 390.5\ V$

$\because E_b \propto I_f\, W_m$ $\therefore E_b \propto I_a\, W_m$ (series)

$\therefore \dfrac{E_{b1}}{E_{b2}} = \dfrac{I_{f1}\, N_{m1}}{I_{f2}\, N_{m2}}$

$\therefore \dfrac{434}{390.5} = \dfrac{20 * 1200}{15 * N_{m2}}$

$\therefore N_{m2} = 1439.63\ rpm$

$P_{a1} = E_{b1} . I_{a1}$

$\therefore P_{a1} = 8680\ W$

$\therefore T_{a1} = P_{a1} / \omega_{m1} = 69.07\ N.m$

$P_{a2} = E_{b2} . I_{a2}$

$\therefore P_{a2} = 5857.5\ W$

$\therefore T_{a2} = P_{a2} / \omega_{m2} = 38.853\ N.m$

(10) shunt, $N_{m1} = 1200$ rpm, $V_a = 420V$, $I_{a1} = 30A$; $R_{add} = ?$

$N_{m2} = 600$ rpm, $I_{a1} = I_{a2}$, $R_a = 3\Omega$?

Solutions

$E_{b1} = V_a - I_{a1} R_a = 420 - 30 * 3 = 330V$

$\because E \propto I_f W_m$

$I_f = \text{Constant}$

لأن طريقة التحكم تتم من خلال مقاومة ال Armature $\Rightarrow I_{f1} = I_{f2}$

$\therefore \frac{E_{b1}}{E_{b2}} = \frac{N_{m1}}{N_{m2}} = \frac{1200}{600}$

$\therefore E_{b1} = 2 E_{b2}$ $\therefore E_{b2} = \frac{1}{2} E_{b1} = 165V$

$\therefore \boxed{E_{b2} = 165V}$

$\because E_{b2} = V_a - I_{a2}(R_a + R_{add})$

$\therefore 165 = 420 - 30(3 + R_{add})$

$8.5 = 3 + R_{add}$

$\therefore \boxed{R_{add} = 5.5\Omega}$